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(54) **Flow metering device.**

(57) In a conveyor means (22, 26, 24) for conveying materials, a flow metering device (26) for metering the weight rate of a materials flow, comprises rotatable impeller means (42/60, 62/88) which are mounted on a drive shaft (32) and are operable to propel the materials. The impeller means (42/60, 62/88), when conveying materials, are subjected to forces which are directed generally perpendicular to the materials engaging surface of said impeller means (42/60, 62/88).

The impeller means (42/60, 62/88) are movable relative to the drive shaft (32) and homing means (-/96) are provided which, in use, tend to position the impeller means (42/60, 62/88) in a home position corresponding to the idle running condition of the flow metering device (26) and which, when materials are being conveyed, permit said generally perpendicular forces to displace said impeller means (42/60, 62/88) opposite to the action of the homing means (-/96). The amount of displacement is indicative of the weight rate of the materials flow.

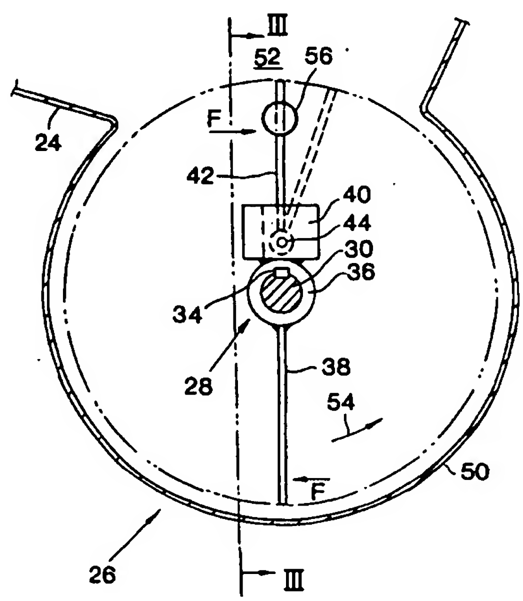

FIG.2

EP 0 463 240 A1

FLOW METERING DEVICE

The present invention is directed to flow metering devices in general and particularly but not exclusively to a tailings flow metering apparatus for use on a combine harvester.

The terms "grain", "straw" and "tailings" are used principally throughout this specification for convenience and it should be understood that these terms are not intended to be limiting. Thus "grain" refers to that part of the crop which is threshed and separated from the discardable part of the crop which is referred to as "straw". Incompletely threshed ears are referred to as "tailings".

In conventional combine harvesters for harvesting crop material, grain is threshed and separated in a threshing and separating mechanism and the separated grain, together with impurities of all sorts, such as chaff, dust, straw particles and tailings, is fed to a cleaning mechanism for cleaning. Clean grain is collected below the cleaning mechanism and fed to a graintank for temporary storage. The tailings are separated from the clean grain and impurities by means of sieves and provisions are taken for recycling the tailings through the combine harvester for reprocessing. This reprocessing involves either recycling the tailings through the threshing and separating mechanism or treating them in a separate tailings rethresher means.

The amount of tailings separated by the cleaning mechanism is determined by the setting of the sieve openings. It is desirable to adjust the sieves in such a manner that the cleaning losses are minimal while at the same time the grain sample in the graintank is acceptable. Therefore, in practice, a certain amount of tailings flow must be accepted in order to reach a practical compromise between cleaning losses and grain sample at a satisfactory capacity level of the combine harvester.

It is generally accepted that the weight rate of the tailings flow may amount to a certain percentage (e.g. in the range of 5 to 10 %) of the grain flow towards the graintank. It is believed that, under such operating conditions, an optimum performance of the combine harvester with regard to capacity and acceptable cleaning losses can be obtained. Indeed, when the tailings flow is too high, then the cleaning mechanism not only has to deal with material which enters the combine for the first time, but also has to reprocess a considerable amount of tailings which, over and over again, recycle through the machine. It will be evident that, under such operating conditions, the cleaning mechanism is used ineffectively resulting in the combine harvester being robbed of capacity. Moreover, a constant overload of the cleaning mechanism ultimately may lead to an incremental rise of the tailings flow ending up with excessive cleaning losses and finally also with blokages of the tailings return system.

On the other hand, a too low tailings flow level could mean that the cleaning mechanism performs inadequately in that a lot of tailings are simply let through and are conveyed together with the clean grain to the graintank. This, of course, shows off in an unacceptable grain sample. If the latter is acceptable however, and if also the cleaning losses are acceptable, then the low tailings flow could be indicative of the combine capacity being insufficiently utilized.

Yet, when harvesting crop material with a combine harvester, the operator is not readily able to determine the amount of tailings being recycled. An extreme method of nonetheless obtaining an indication of the tailings flow consists in an instantaneous shut down of the combine engine during the harvesting operation (so called "kill-stop") whereby all driven combine components come to an immediate stop. A glance in the tailings return system then may provide a very subjective and trifling indication of the volume of tailings being conveyed. However, weight and weight rates are preferred by the operator. Moreover, it will be appreciated that the albove method is not to be recommended from a technical and functional point of view.

In case provisions are taken for diverting the tailings return system over the operator's platform, then the operator has the possibility to observe the tailings flow in the return system on-the-go. However, in a fast moving trarsport element, only volumes of tailings can be estimated which do not allow for any reliable quantification and do not provide any correlation to the clean grain being harvested.

Instead of diverting the tailings flow, another person could assist the operator by running along the combine harvester during operation and also observe the tailings flow in the return system on-the-go. This method however suffers from the same disadvantages as discussed hereabove and moreover is very impractical and extremely dangerous. Without doubt, it therefore should be avoided.

Various attemps have already been made to provide material flow metering devices. Some of the prior art devices provide volumetric measurements. However, as said already, weights and weight rates are preferred over volumetric measurements. Conversion of volume to weight is, of course, possible by using the specific weight figures for the material being conveyed. However,

specific weight figures vary very substantially whereby it is necessary to also measure these values. In practice, it has been found that the conversion of volume to weight seldomly is done accurately and often is a cause for substantial errors.

In ISA Transactions Vol. 5. No. 1 dd January 1966 a mass flowmeter for granular material is shown of which the measuring principle is based on an angular momentuma change. The meter consists of a set of vertical vanes forming a rotor which is rotated around a vertical shaft by a synchronous motor. The granular material of which the flow rate is to be determined, falls on a core at the top of the rotor and is then directed into the top of the rotating vanes near the axis of rotation. The material slides along the vanes and is thrown from the device at the outer radius thereof. The motor which drives the rotor by means of a flat belt, is rigidly connected to a supporting shaft onto which the rotor is rotatably mounted. The change in angular momentum of the granular material passing through the meter causes a torque in the supporting shaft, which is registered by means of strain gauges on said supporting shaft.

It is observed that the meter just described has only limited use for stationary machinery as not only the rotor but also the material entrance always should be positioned perfectly vertically. Indeed, since the measuring technique requires that the granular material falls onto the rotor structure i.e. enters the flowmeter under influence of gravitational forces only, an inclination of the rotor away from the vertical is not allowed as this would disturb the fow rate measurements. This prior art meter furthermore also suffers from the disadvantage that vibrations of the motor could overshadow the created torque, especially when only small amounts of material are conducted through the rotor. In addition, it must be considered that the measured torque consists of the rotor drive torque on the one hand but also of the empty running motor torque on the other hand. As the latter may equal or even exceed the former, inaccurate results are likely to be obtained. Also, inherent to the measuring principle, the motor for driving the meter should be located in the immediate vicinity thereof as the path for transmitting the torque should be limited to the drive belt and the motor support only.

It therefore is the objective of the present invention to provide a weight rate metering device such as a tailings flow metering apparatus for measuring the tailings flow in a combine harvester, which overcomes the disadvantages described above.

According to the invention, a flow metering device is provided for metering the weight rate of a materials flow in a conveyor means and which comprises rotatable impeller means mounted on a drive shaft; said impeller means being operable to propel materials while being subjected to reaction forces exerted by said materials as a result of said propelling action.

Said flow metering device is characterized in that :

- on the one hand, the impeller means thereof are movable relative to the drive shaft; and
- on the other hand, it further also comprises :

. homing arrangements which, in use of the flow metering device, tend to position the impeller means in a home position corresponding to the idle running condition of the flow metering device and which, when materials are being propelled, permit said reaction forces to displace said impeller means opposite to the action of the homing arrangements; the amount of displacement being indicative of the weight rate of the materials flow;

. sensor means operable to detect the amount of displacement of the impeller means relative to the drive shaft and to produce a signal representative thereof, and

. indicator means operatively coupled to the sensor means to provide an indication of the weight rate of the materials flow.

Preferably, the conveyor means comprises an auger rotatably mounted on an auger shaft within an auger trough. The drive shaft supporting the impeller means is formed by an axial extension of said auger shaft whereby the impeller means receive motive power from the auger shaft and are supplied with materials from the auger in a generally axial direction. The impeller means, which are mounted within a generally cylindrical impeller housing comprising a circumferential outlet, are operable to discharge materials through said outlet in a generally radial direction.

The sensor means is coupled to a micro-processor circuitry for processing the signals received therefrom and for steering the indicator means in order to provide an indication of the weight rate of the materials flow. In addition, the same signals are analysed for determining the rotational speed of the auger shaft.

In a preferred embodiment of the present invention, the impeller means form part of an impeller rotor, further also comprising an impeller blade rigidly connected to the drive shaft. The homing arrangement is formed by the impeller means being hingeably connected to the drive shaft at an eccentric location relative thereto in a manner such that during rotation of the impeller rotor, centrifugal forces act upon the impeller means for urging the same towards their home position.

A flow metering device in accordance with the present invention will now be described in greater detail, by way of example, with reference to the

accompanying drawings, in which:

Figure 1 is a diagrammatic side elevation view of a combine harvester incorporating the present invention;

Figure 2 is an enlarged sectional side view of a preferred embodiment of the flow metering device according to the invention;

Figure 3 is a cross sectional view taken along the lines III-III of Figure 2;

Figures 4 and 5 are views similar to respectively Figures 2 and 3 but representing an alternative embodiment, and

Figure 6 is a view similar to Figures 3 and 5 but illustrating still another embodiment.

With reference to the drawings, particularly Figure 1, a combine harvester, generally indicated at 1, comprises a base unit 2 including a main chassis or frame 3 supported on a front pair of drive wheels 4 and a rear pair of steerable wheels 5. A conventional crop harvesting header 6 extends forwardly of the frame 3 and is operable to sever standing crop material and initiate the crop harvesting process. A straw elevator 7 interconnects the header 6 and the base unit 2 and houses a conveyor 8 for transferring severed crop material rearwardly from the header 6.

A threshing and separating mechanism 9 is suitably housed within the base unit 2 rearwardly of the straw elevator 7 to receive the severed crop material therefrom and subsequently thresh and separate the edible grain from the straw. The separated grain, together with impurities such as chaff, dust and straw particles falls onto a grain cleaning mechanism 10 which comprises means to separate chaff and other impurities from the grain, and means to separate unthreshed parts, known as tailings.

The cleaned grain is collected in a clean grain trough 12 which extends transversely of the combine harvester 1 and contains a clean grain auger 14 for conveying the collected grain towards a clean grain elevator 16 which elevates the clean grain into a graintank 18.

A tailings auger trough 20 also extends transversely of the machine and comprises a tailings auger 22 (not shown in Figure 1) for transporting the collected tailings to one side of the combine harvester 1. At this side, an elevator conveyor 24 is operable to return the tailings towards the threshing and separating mechanism 9 for repeated threshing and separating action.

An additional tailings transfer means indicated at 26 is installed between the tailings auger 22 and the elevator conveyor 24 for ensuring a smooth flow of tailings material in the transitional area between both mentioned components 22 and 24. Besides transporting tailings material, the additional tailings transfer means 26 also is used to measure the weight rate of the tailings flow in a manner which will be described in more details hereinafter.

In Figures 2 and 3, a preferred embodiment of the tailings transfer means 26 can be seen, comprising an impeller rotor 28 mounted on an extended end portion 30 of the tailings auger shaft 32 and fixed thereto by means of a key 34. The rotor 28 comprises a central hub 36 with an impeller blade 38 welded thereon in the axial direction. At the diametrically opposite side of the hub 36 relative to the impeller blade 38, a U-shaped member 40 is welded on the hub 36 parallel to the impeller blade 38 and is operable to hingeably support an impeller means 42. To this end, the impeller means 42 is provided with a hinge shaft 44 conically shaped at both ends for being received respectively by a bore 46 in one leg of the U-shaped member 40 and by a hollow threaded rod 48 inserted through a threaded bore in the other leg of the U-shaped member 40. By adjusting the threaded rod 48, the pressure on the conical surfaces of the hinge shaft 44 can be minimized so as to obtain a low friction hinge.

The impeller rotor 28 is surrounded by a cylindrically shaped housing 50 arranged coaxially with the auger shaft 32 and having an outer diameter which is equal or greater than the outer diameter of the tailings auger trough 20. The housing 50 is open at its top portion 52 for allowing tailings to flow from the impeller rotor 28 towards the housing of the elevator conveyor 24.

During the idle running condition of the impeller rotor 28, centrifugal forces acting on the impeller means 42 aim to align the same with the impeller blade 38, as seen in full lines in Figure 2. When tailings are being conveyed, the tailings auger 22 forcefully distributes the transported material over the transitional area between the auger 22 and the impeller rotor 28 whereafter the tailings are forced towards the outer circumference of the housing 50 by the intermediary of the rotor 28, rotating in the direction of arrow 54. The tailings finally are released at the open top 52 of the housing 50 and are received by the elevator conveyor 24 which takes care of further transport as already explained above.

Tailings conveyed by the auger 22 basically only have an axially directed speed. When entering the rotor housing 50 however, the flow path of the tailings is deflected in the rotational direction 54 of the rotor 28 i.e. perpendicular to the tailings engaging surfaces of the impeller blade 38 and the impeller means 42. Changing the angular momentum of the tailings flow results in forces F experienced in the perpendicular direction to the tailings engaging surfaces mentioned hereabove. Considering the impeller blade 38, the force F creates a torque in the shaft end 30 because of the fixed

ccnnection between the two components 38 and 30.

The impeller means 42 on the other hand is swung rearwardly opposite to the direction of rotation 54 around the hinge shaft 44 when experiencing the perpendicular force F. It will be appreciated that the more tailings are being conveyed, the larger the forces F will be and consequently the further the impeller means 42 will be inclined rearwardly. One rearwardly inclined position out of a range of possible positions is illustrated in dashed lines in Figure 2. Each such position of the impeller means 42 is defined by an equilibrium of oppositely directed forces acting thereon, being on the one hand the force F proportional to the weight rate of the tailings flow and on the other hand an oppositely directed component of the centrifugal force. Consequently, when the tailings flow is interrupted, the force F disappears, thereby allowing the impeller means 42 to be called back by the centrifugal force to a home position in alignment with the impeller blade 28.

Based on the above reasoning, it will be understood that the amount of displacement of the impeller mears 42 relative to the reference impeller blade 38 provides an indication of the weight rate of the material flow. To enable measuring said displacement, a sensor 56 is secured to the rotor housing 50 close to the outer periphery of the rotor 28 and parallel to the auger shaft 32. The sensor 56 is operable to detect the alternating passing-by of the rotor members 38 and 42 and to produce electrical signals in response thereto which are transmitted to signal processing means (not shown), such as a micro-processor for example. Consequently, for each revolution of the rotor 28, the micro-processor is able to calculate the time lapses, on the one hand, between the consecutive passing-by of the impeller blade 38 and the impeller means 42 and subsequently, on the other hand, between the consecutive passing-by of the impeller means 42 and the impeller blade 38.

Assuming that there is no tailings flow and that the rotating impeller means 42 is not influenced by air resistance, the latter will be perfectly aligned with the impeller blade 38, resulting in the two time lapses mentioned above being identical. However, in practice, air is always impelled by the impeller rotor 28 so that the impeller means 42 are slightly inclined rearwardly when seen in the direction of rotation 54 even in the idle running condition of said rotor 28. When starting up the combine harvester 1 and before any tailings are flowing, this deviation is recorded by the micro-processor for taking account thereof in further calculations.

As soon as tailings are being conveyed, the impeller means 42 are forced to a rearwardly inclined position for reasons already explained above. In so doing, the distance from the impeller means 42 to the impeller blade 38, measured along the path of rotation 54, increases, resulting naturally in the time lapse between the passing-by of the impeller blade 38 and the impeller means 42 in front of the detector head to increase with a corresponding amount. It will be appreciated that, at the same time, the distance from the impeller blade 38 to the impeller means 42, measured along the path of rotation 54, decreases, what decreases the time lapse associated therewith.

During normal harvesting operation of the combine harvester 1, the micro-processor continuously derives time lapses from the signals received from the sensor 56; time lapses which vary in accordance with the amount of material beirg conveyed and which are fed to an algorithm in the micro-processor for providing an indication of the weight rate of the tailings flow. Said indication can be made accessible to the operator by means of a digital display screen (not shown) on the operator's platform. In combination with the visual display, an alarm may sound when an excessive tailings flow, which ultimately could lead to blockages of the tailings return system, is being measured.

The micro-processor further can ba relied upon for processing signals received from a clean grain flow metering device and as such providing an indication of the weight rate of the clean grain flow. All this in combination with on-the-go-throughput signals and grainloss signals enables the operator to choose for an optimum condition with regard to harvesting speed and machine settings for harvesting at an acceptable tailings flow level.

Besides providing signals for determining the tailings flow, the sensor 56, in addition, is operable by its nature of detecting rotating elements, to relay signals, eventually the same as referred to hereabove, to the micro-processor for calculating the rotational speed of the impeller rotor 28 and hence of the tailings auger 22. Referring more specifically to Figures 2 and 3, the signals which are created by the impeller blade 38 and the impeller means 42 rotating in front of the sensor head not only are used by the micro-processor to measure the tailings flow, but also serve as a basis for RPM measurements. Indeed, since the impeller blade 38 takes a fixed position in relation to the auger shaft 32, the micro-processor is capable, by analysis of the signals to calculate the rotational speed of the impeller rotor 28 and to steer an RPM monitor for providing an RPM reading.

An alternative embodiment of the present invention is shown in Figures 4 and 5. Structural parts wich already have been discussed in the first embodiment and which have not been modified, are designated with the same reference numbers. On the extended end portion 30 of the tailings

auger shaft 32, an impeller rotor 58 is provided comprising impeller means 60 and 62 in the form of blades, which are rigidly secured, at diametrically opposite sides, to a sleeve member 64 which in turn is rotatably supported on a central hub 66 by means of a pair of bushings 68. The hub 66 is provided with an eccentric bore fit to slide over the shaft end 30 and for beirg fixed thereto by a key 34. At the right hand side as seen ir Figure 5, a cross-shaped gauging member 70 having a circular portion 72 with four equiangularly spaced extensions 74 thereon is connected to the hub 66. Inwardly thereof, a similarly shaped gauging member 76 having four extensions 78 of which the outer edges reach radially further than the extensions 74, is secured to the sleeve member 64. In the position of the impeller rotor 58 shown in Figure 4, the extensions 74 and 78 overlap, leaving bowl-shaped spaces 80 inbetween. One of the extensions 78 of the member 76 comprises an abutment tab 82 for reasons which will be discussed hereafter.

It will be observed in Figure 4 that the impeller blade 60 is made heavier than the blade 62, meaning that the centre of gravity of the impeller unit formed by the blades 60, 62 and the sleeve member 64 is located in the impeller blade 60, somewhere along the centre line thereof. During the the running condition of the impeller rotor 58, of which Figure 4 is an instantaneous exposure, the shaft end portion 30 together with the rotor 58 are rotated in the direction of arrow 54. Centrifugal forces acting on the centre of gravity of the impeller rotor 58 aim to maintain said rotor 58 in a position of minimal potential energy, being with the centre of gravity in alignment with the connecting line between the rotational centre 65 of the shaft 30 on the one hand and the rotational centre 67 of the sleeve member 64 on the other hand.

Under these operating conditions, the extensions 74 and 78 overlap, as already mentioned. During one revolution of the impeller rotor 58, the sensor 56 therefore detects four times the passing-by of the extensions 74, 78 and four times the absence thereof, namely when the open spaces 80 pass in front of the sensor 56.

Comparable to the situation already described in connection with the first embodiment of Figures 2 and 3, forces F are experienced perpendicularly to the material engaging surfaces of the impeller blades 60 and 62 when tailings are being conveyed by the impeller rotor 58. Said forces F cause the blades 60, 62 and the sleeve member 64 to rotate on the bushings 68 in a clockwise direction as seen in Figure 4, i.e. in a direction opposite to the sense of rotation 54 of the shaft 30. As a result, the centre of gravity of the impeller rotor 58 is moved from its rest or home position whereby the centrifugal force acting thereon is deflected from its pure radial direction, creating a tangential component directed opposite to the forces F. Said tangential component is capable of calling the rotor 58 back to its rest or home position shown in Figure 4 when the tailings flow is interrupted and the forces F cease to exist.

Turning back to the situation in which the rotor 58 is moved from its rest or home position, it will be understood that, by this action, the open spaces 80 gradually are reduced by the extensions 78 which emerge from behind the extensions 74. In Figure 4, a situation is illustrated in dashed lines in which the open spaces 80 are already half-way closed. This situation corresponds to a certain amount of tailings being transported and is captured by the sensor 56 by detecting the open spaces 80 during a reduced period of time when compared to the idle running condition of the impeller rotor 58.

An extreme position of the extension 78 closing off the spaces 80 completely is reached when the abutment tab 82 engages the adjacent extension 74 whereby further backward rotation of the blades 60 and 62 is prevented. This position is obtained when the impeller rotor 58 is operating at full capacity. Since the spaces 80 are non-existant at that moment, the sensor 56 constantly detects the alternating presence of the extensions 74 and 78 without any interruptions inbetween.

It will be appreciated from the above that, according to the amount of free space 80 which is detected by the sensor 56, signals are transmitted to the micro-processor for deriving therefrom the weight rate of the tailings flow.

Besides the function already discussed, the abutment tab 82 further also serves a totally different purpose. Indeed, when starting up the tailings return system, the unit formed by the blades 60, 62 and the sleeve member 64 could have a tendency not to rotate in unison with the hub 66 as there is no structural drive transmitting element between the hub 66 and the sleeve member 64. Accordingly, when the hub 66 and hence the extensions 74 start to rotate while the blades 60, 62 stay immobile by their inertia, one of the extensions 74 approaches and engages the abutment tab 82 whereby the blades 60, 62 are equally forced to rotate. Once in rotation, the centrifugal forces urge the impeller blades 60, 62 forwardly to their home position shown in Figure 4, obviating the further need of the abutment tab 82 as drive transmitting element.

With reference to Figure 6, still a further embodiment is shown which differs from the two embodiments already described in that the impeller rotor no longer is urged to a home position by means of centrifugal forces. More specifically, an impeller rotor 84 is concentrically mounted on the

auger shaft extension 30 and is rotatable relative thereto by the intermediary of a pair of bearings 86. The rotor 84 comprises a pair of impeller means 88 in the form of blades which are welded on a hub 90. The latter extends through the impeller housing 50 and, at the outer side thereof, carries a gauging flange in the form of a disc 92 which is toothed at its outer edge. Next to the disc 92, at the side facing away from the impeller housing 50, a further gauging flange or disc 94, equally toothed at is outer edge, is firmly secured to the shaft end portion 30 for rotating in unison therewith.

Inbetween the discs 92 and 94, a set of springs 96 is provided for drivingly interconnecting the disc 94 to the disc 92 and hence the auger shaft 32 to the impeller rotor 84. To this end, the respective ends of each spring 96 are secured to anchor points (not shown) on respectively the disc 92 and 94.

When the auger 22 is set in motion, the disc 94 pulls on the springs 96 for trailing the disc 92 behind. As in the idle running condition of the impeller rotor 84 only air resistance is felt by the impeller blades 88, only minimal force is required to rotate the same and thus the springs 96 are just slightly tensioned. Under these operating conditions, the disc 92 takes up a fixed relative position with respect to the disc 94. As already mentioned, each disc 92, 94 is toothed, however preferably with the teeth in the form of steps, enabling a pair of sensors 98 to either detect the presence of such a step or to sense the absence thereof. Signals produced in accordance therewith are processed by a micro processor (not shown) for assessing the position of the discs 92 relative to each other.

Under loaded conditions of the rotor 84, the blades 88 are subjected to a substantial torque as the tailings are impelled and ejected from the rotor housing 50. The foregoing causes the rotor 84 to pull with increased tension on the springs 96 whereby the disc 92 lags the disc 94 at an increased relative distance. Any decrease in the tailings flow is immediately responded to by the springs 96 which act as homing means whereby the impeller rotor 84 tends to revert to its home position.

It will be appreciated from the foregoing that the relative position of the discs 92 and 94 with respect to each other varies in accordance with the weight rate of the tailings flow and thus the signals produced by the sensors 98 are applicable to measure the amount of tailings which are conveyed.

The above described embodiments for measuring the tailings flow in a combine harvester all have the following specific advantages over prior art arrangements :

- very compact in construction;
- less sensitive to variations in inclination when installed on a mobile machine;
- easy to retrofit on existing machines;
- double use of the impeller rotor : as tailings transfer means in the tailings return system and as tailings flow metering device, hence reduced cost price;
- flow metering device also serves as RPM meter, saving extra electronic hardware;
- self-cleaning action whereby adverse effects of encrustation on the impeller rotor are eliminated.

So far, the invention and its operation have been described in connection with a tailings transfer means 26 inbetween the tailings bottom auger 22 and the elevator conveyor 24 for metering the tailings flow. The invention also can be installed at any other location in the tailings return line, provided an auger conveyor is mounted immediately upstream of the flow metering device for possitively conveying the tailings thereto. For example, in case the elevator conveyor 24 comprises an auger conveyor, the flow metering device according to the invention advantageously can be installed at the transitional zone between the elevator conveyor 24 and the threshing and separating mechanism 9. More specifically and comparable with the above described embodiments, the flow metering device preferably can be installed on an axial extension of the auger conveyor 24. The orientation of the flow metering device is not really important as the influence of gravity forces is neglectable in comparison with the centrifugal forces which are created by the rotating flow metering device. The invention obviously also effectively can be used in other combinations such as for metering the clean grain flow in the clean grain elevator 16 for example. In this connection, an appropriate place for installing the flow metering device could be found on top of the clean grain elevator 16 where the clean grain is released in the graintank 18.

The flow metering device according to the invention also can be used in other agricultural and non-agricultural equipment which either can be mobile or stationary. Accordingly, the invention is not limited to the application on a combine harvester or any other agricultural machine or equipment handling or processing granular material. It is even not limited to the use for metering granular material as such. Indeed, it also successfully can be used for metering the flow rate of other materials such as powdery material for example.

While the preferred structures, in which the principles of the present invention have been incorporated, are described above and are shown in the accompagnying drawings, it is to be understood that the invention is not to be limited to the particular details as described above and shown in said drawings, but that, in fact, widely different means

may be employed in the practice of the broader aspects of the invention.

Claims

1. In a conveyor means (22, 26, 24) for conveying material, a flow metering device (26) for metering the weight rate of a materials flow comprising rotatable impeller means (42/60, 62/88) mounted on a drive shaft (30); said impeller means (42/60, 62/88) being operable to propel materials while being subjected to reaction forces exerted by said materials as an result of said propelling action;
said flow metering device (26) being characterized in that :
- on the one hand, the impeller means (42/60, 62/88) thereof are movable relative to the drive shaft (32); and
- on the other hand, it further also comprises :
. homing arrangements (-/-/96) which, in use of the flow metering device (26), tend to position the impeller means (42/60, 62/88) in a home position corresponding to the idle running condition of the flow metering device (26) and which, when materials are being propelled, permit said reaction forces to displace said impeller means (42/60, 62/88) opposite to the action of the homing arrangements (-/-/96); the amount of relative displacement being indicative of the weight rate of the materials flow;
. sensor means (56/98) operable to detect the amount of displacement of the impeller means (42/60, 62/88) relative to the drive shaft (32) and to produce a signal representative thereof, and
. indicator means operatively coupled to the sensor means (56/98) to provice an indication of the weight rate of the materials flow.
2. A flow metering device according to claim 1 characterized in that it further also comprises a microprocessor circuitry to which the sensor means (56/98) and the indicator means are coupled for processing the signals received from the sensor means (56/98) and for steering the indicator means therewith.
3. A flow metering device according to claim 2 characterized in that the micro-processor additionally also is coupled to an RPM monitor and utilizes the signals received from the sensor means (56/98) to steer said RPM monitor for providing an RPM reading of the drive shaft's rotational speed.
4. A flow metering device according to any of the preceding claims characterized in that :
- the conveyor means (22, 26, 24) comprise an auger (22) rotatably mounted within an auger trough (20) and including an auger shaft (32); and
- the drive shaft supporting the impeller means (42/60, 62/88) is formed by an axial extension (30) of the auger shaft (32); the arrangement being such that, in use, the impeller means (42/60, 62/88) receive motive power from said auger shaft (32) and the auger (22) supplies materials to the impeller means (42/60, 62/88) generally in the axial direction thereof.
5. A flow meteing device according to any of the preceding claims characterized in that the impeller means (42/60, 62/88) are mounted within a generally cylindrical impeller housing (50) comprising a circumferential outlet (52); the impeller means (42/60, 62/88) being operable to discharge materials through said outlet (52) in a generally radial direction.
6. A flow metering device according to any of the preceding claims characterized in that :
- the impeller means (42) form part of an impeller rotor (28) further also comprising an impeller blade (38) rigidly connected to the drive shaft (30); and
- the homing arrangement is formed by the impeller means (42) being hingeably connected to the drive shaft (30) at an eccentric location relative thereto; the arrangement being such that, during rotation of the impeller rotor (28), centrifugal forces act upon the impeller means (42) which urge these impeller means (42) towards said home position.
7. A flow metering device acc ording to claim 6 characterized in that the impeller rotor (28) comprises :
- a central hub (36) keyed to the drive shaft (30); the impeller blade (38) being rigidly connected to said hub (36); and
- a mounting member (40) rigidly connected to said central hub (36) at a generally diametrically opposite location relative to the impeller blade (38) thereon; said impeller means (42) being hingeably connected to said mounting member (40).
8. A flow metering device according to claim 7 characterized in that:
- the mounting member (40) is generally U-shaped and comprises a mounting bore (46) in one limb thereof and a hollow mounting element (48) supported on the other limb thereof in axial alignment with said mounting bore (46) and for adjustment in the axial direction relative to said bore (46); and
- the impeller means (42) comprise a hinge shaft (44) provided with oppositely oriented conical ends hingeably received between said mounting bore (46) and said mounting element (48).
9. A flow metering device according to any of the claims 6 to 8, characterized in that the impeller means (42), when propelling materials, are hinged, under influence of said reaction forces, opposite to the direction of rotation (54) of the impeller rotor (28) away from said home position and towards a lagging position in which an equilibrium is established between said centrifugal forces and said reaction forces; the amount of angular displacement of the impeller means (42) between said home position and said lagging position being de-

tected by the sensor means (56) as a measure for the weight rate of the materials being propelled by the impeller rotor (28).

10. A flow metering device according to any fo the claims 6 to 9, characterized in that, in said home position, the impeller means (42) extend generally radially relative to the drive shaft (30).

11. A flow metering device acccrding to any of the claims 1 to 5 characterized in that the homing arrangement is formed by :

- the drive shaft (30) being rotatable around an axis of rotation (65) and comprising bearing means (66) disposed eccentrically with respect to said axis of rotation (65);
- the impeller means (60, 62) comprising a sleeve (64) rotatably mounted on the eccentric bearing means (66) whereby the center (67) of this sleeve (64) is offset with respect to said axis of rotation (65); and
- the impeller means (60, 62) having a center of gravity positioned at a distance from said sleeve center (67); the arrangement being such that, in use, centrifugal forces acting on the impeller means (60, 62) urge these impeller means (60, 62) towards said home position.

12. A flow metering device according to claim 11 characterized in that :

- in said home position, the center of gravity of the impeller means (60, 62) is positioned generally along or proximate to the straight line extending through said axis of rotation (65) of the drive shaft (30) and said sleeve center (67); and
- the impeller means (60, 62), when propelling materials, angularly are displaced, under influence of said reaction forces, around said bearing means (66) in the direction opposite to the direction of rotation (54) of the drive shaft (30) away from said home position and towards a lagging position in which an equilibrium is established between said centrifugal forces and said reaction forces; the amount of angular displacement of the impeller means (60, 62) between said home position and said lagging position being detected by the sensor means (56) as a measure for the weight rate of the materials being propelled by the impeller means (60, 62).

13. A flow metering device according to claim 11 or 12 characterized in that :

- the eccentric bearing means on the drive shaft (30) are formed by an eccentric hub (66) keyed on said shaft (30); and
- the impeller means comprise a pair of diametrically opposite impeller blades (60, 62) fixedly attached to said sleeve (64); one of said blades (60) being heavier than the other (62) whereby said center of gravity of the impeller means (60, 62) is offset relative to said sleeve center (67).

14. A flow metering device accor ding to any of the claims 11 to 13 characterized in that :

- a first gauging member (70) is fixedly attached to the drive shaft (30) for rotation in unison therewith; and
- a second gauging member (76) is fixedly attached to the impeller means (60, 62) for movement in unison therewith; said first and second gauging members (70, 76) being disposed for movement in the proximity of the sensor means (56) to permit said sensor means (56) to detect the angular displacement between said first and second gauging members (70, 76).

15. A flow metering device according to claim 14 characterized in that :

- the first and second gauging member are formed by toothed flanges (70, 76) attached to respectively the drive shaft (30) and the impeller means (60, 62) and extending proximate and generally parallel to each other; the teeth (74, 78) of said flanges (70, 76) when seen in the axial direction of the impeller means (60, 62), generally overlapping each other when said impeller means (60, 62) are in said home position and being displaced with respect to each other in accordance with the relative angular displacement of the impeller means (60, 62) under influence of said reaction forces whereby, as seen in said axial direction, the width of the pairs of overlapping teeth (74, 78) is increased accordingly; and
- the sensor means (56) are disposed to detect said variation in said width as a measure for the weight rate of the materials being propelled by the impeller means (60, 62).

16. A flow metering device according to claim 15 characterized in that an abutment member (82) is attached to one of the toothed flanges (70, 76) in a manner for the other toothed flange to abut thereagainst upon said flanges (70, 76) being displaced relative to each other over an angle corresponding to the circumferential width of the spacing (80) between adjacent teeth (74, 78).

17. A flow metering device according to any of the claims 1 to 5 characterized in that :

- the impeller means (88) are formed by an impeller rotor (84) extending coaxially with the drive shaft (30) and freely rotatably mounted thereon; said rotor (84) including generally radially extending impeller blades (88); and
- the homing arrangement comprises resilient means (96) drivingly coupling the drive shaft (30) to the impeller rotor (84) and operable, in use, to urge the impeller rotor (84) towards said home position and to permit said impeller rotor (84), when propelling materials, to be displaced angularly, under influence of said reaction forces, relative to said drive shaft (30) in the direction opposite to the direction of rotation (54) of this drive shaft (30) away from said home position and towards a lag-

ging position in which an equilibrium is established between said reaction forces and the resilient forces urging the impeller rotor (84) in the direction towards its home position; the amount of angular displacement between said home position and said lagging position being detected by the sensor means (98) as a measure for the weight rate of the material being propelled by the impeller rotor (84).

18. A flow metering device according to claim 17 characterized in that :

- a first gauging flange (94) is fixedly attached to the drive shaft (30) for rotation in unison therewith;
- a second gauging flange (92) is fixedly attached to the impeller rotor (84) for movement in unison therewith generally in the proximity of and parallel to said first gauging flange (94);
- said resilient means (96) are positioned inbetween said first and second flanges (94, 92) and drivingly interconnect these flanges (94, 92); the arrangement being such that any relative displacement of said flanges (94, 92) corresponds to the same displacement of the impeller rotor (84) relative to the drive shaft (30); and
- the sensor means (98) are disposed to detect said relative displacement of said flanges (94, 92) as a measure for the weight rate of the materials being propelled by the impeller rotor (84).

19. A flow metering device according to any of the preceding claims characterized in that this device is used on a combine harvester to provide an on-the-go weight rate indication of the tailings return flow and/or the clean grain flow in the machine.

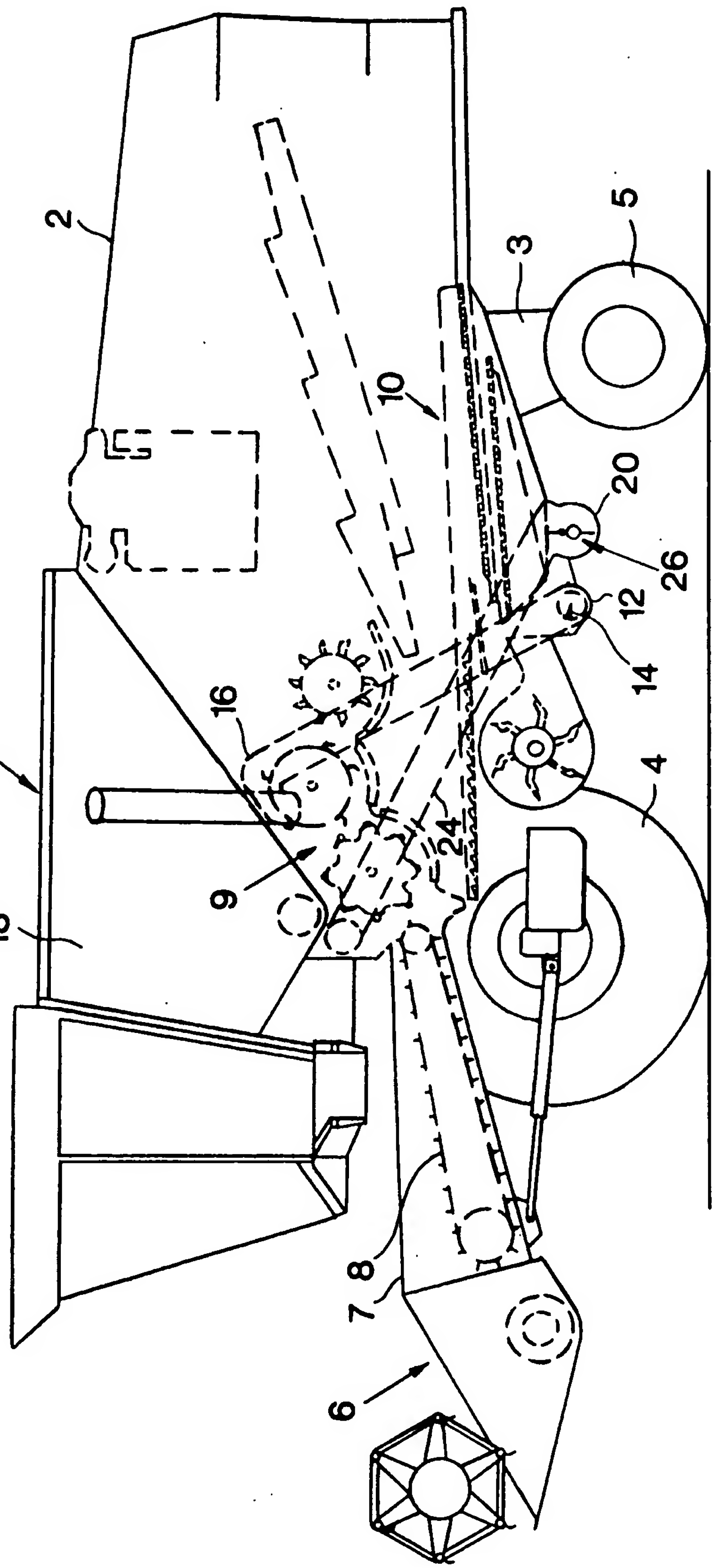

FIG.1

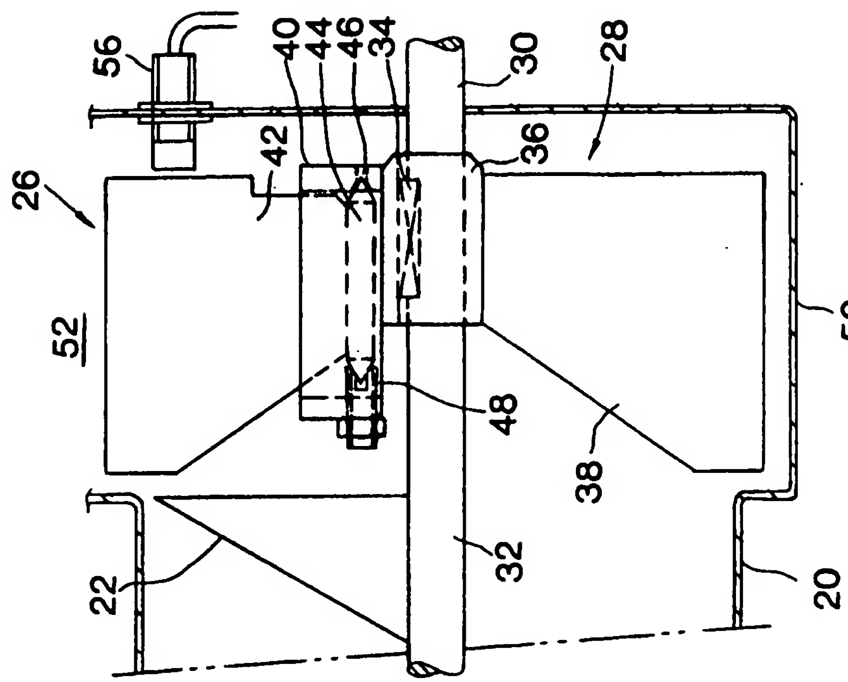
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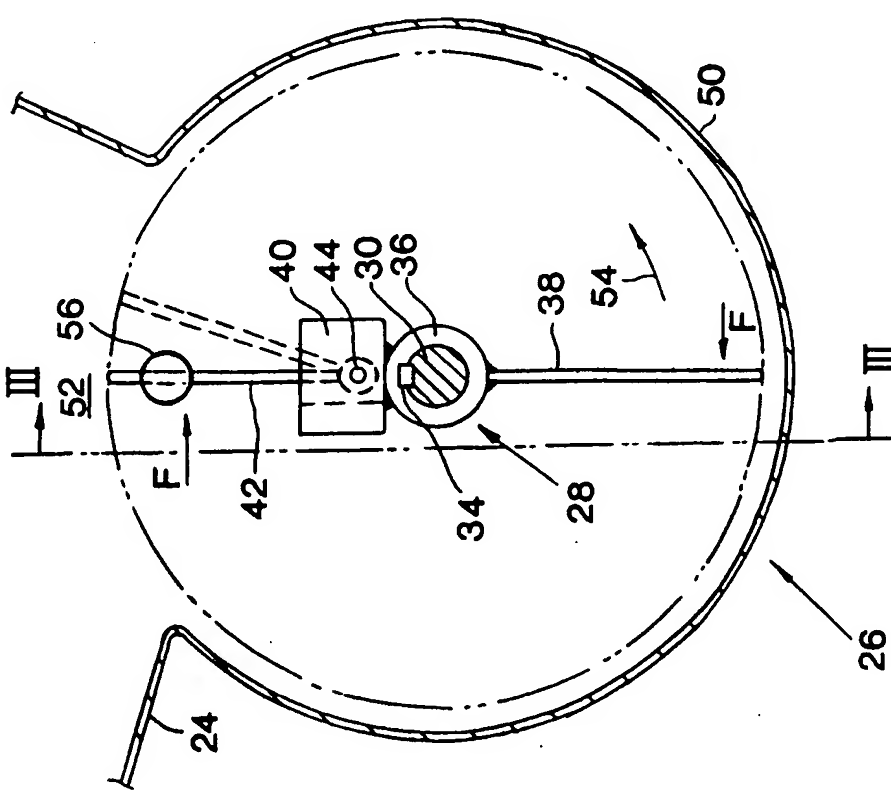
FIG.3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38
54
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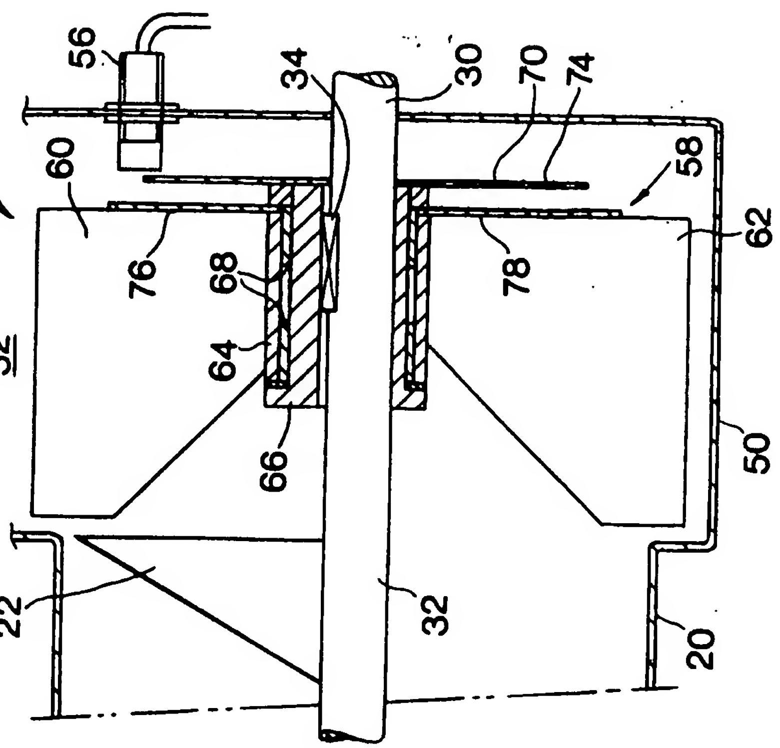
III
52
F
42
34
28
F
III
26
24

FIG.2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30
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76
78
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68
64
66
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32
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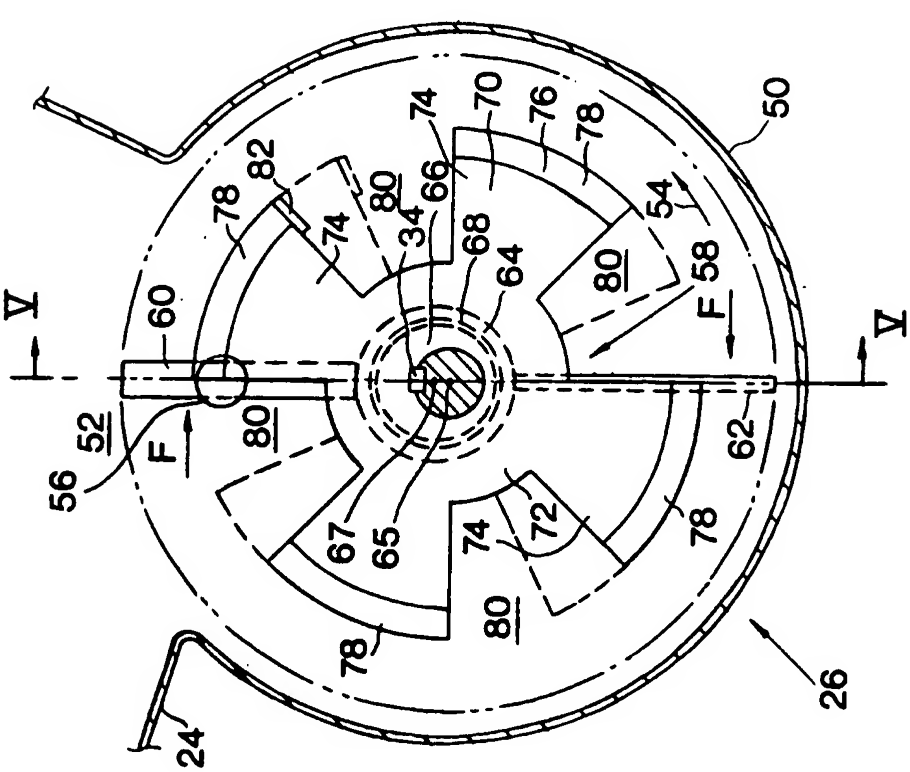
FIG.5


V
V
60
52
56
F
F
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82
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74
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34
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62
67
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80
78
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26

FIG.4

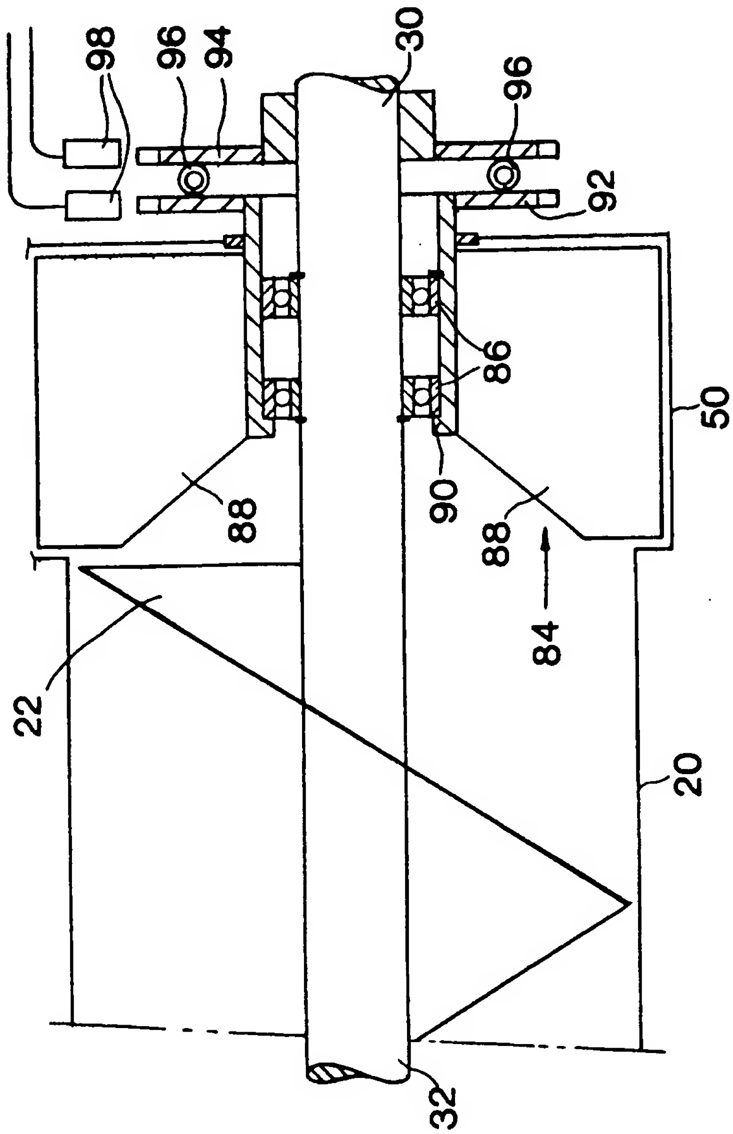

FIG.6

European
Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 20 1668

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-3 807 229 (CHILES) * Column 2, line 64 - column 3, line 54; figures *	1,17	G 01 F 1/82 G 01 F 1/80 A 01 F 12/52 A 01 D 41/12
Y		4,5,19	
A		18	
Y	DE-A-2 009 860 (WISSENSCHAFTLICH-TECHNISCHES ZENTRUM FÜR LANDTECHNIK) * The whole document *	19	
Y	FR-A-2 285 062 (MASCHINENFABRIK FAHR AG GOTT-MADINGEN) * Page 5, line 11 - page 6, line 10; figure 1 *	4,5	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G 01 F
A 01 F
A 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	18 February 91	ROSE A.R.P.

CATEGORY OF CITED DOCUMENTS

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